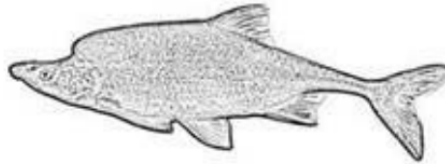


# **Little Colorado River Fish Monitoring Lower 1,200m 2014 Annual Report**



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Submitted to: Grand Canyon Monitoring and Research Center, Flagstaff, AZ

Cooperative Agreement # G09AC00036

February 2015

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# Little Colorado River Fish Monitoring Lower 1,200m - 2014 Annual Report

By Lisa K. Winters and Robin J. Osterhoudt

## Abstract

The Arizona Game and Fish Department has conducted annual hoop net monitoring of fishes in the lower 1,200 meters of the Little Colorado River (LCR) since 1987 in order to monitor status and trends of the fish community, in particular the endangered humpback chub. Standardized sampling is conducted for 20–30 days each spring (April–May) to capture fish during spawning migrations. Catch per unit effort (CPUE; fish/24 hrs) data is used to estimate relative abundances of fish of varying size classes. Additionally, collected data assesses annual native species length-frequency distributions and overall species composition in the river.

Native fish species including humpback chub, flannelmouth sucker, bluehead sucker, and speckled dace continued to dominate the catch composition of the lower 1,200 m of the Little Colorado River in 2014. Catch rates of humpback chub were approximately 1.5 fish per 24 hours, lower than 2013, but not significantly different over the long term. Juvenile, subadult, and adult size classes were all represented; juvenile fish (< 150 mm TL) were poorly represented compared to previous years. Flannelmouth sucker and bluehead sucker were both caught at rates around 1.4 fish/24 hours, not significantly different than in the past five years. Both juvenile and adult size classes of suckers were captured, few of which were recaptures (previously tagged).

Nonnative fish have been captured within the reach since sampling began in 1987. Fathead minnow and red shiner were found in much smaller quantities in 2014 than in previous years. Black bullheads have only appeared during sampling in the past decade. Additionally, rainbow trout continue to persist in low numbers.

## Introduction

The Glen Canyon Dam Adaptive Management Program was initiated in 1996 with the completion of the Environmental Impact Statement on Operations of Glen Canyon Dam (USBR 1995). This Program gave federal authority to protect and mitigate adverse impacts to Colorado River resources downstream from Glen Canyon Dam. The U.S. Geological Survey's Grand Canyon Monitoring and Research Center is the primary science provider responsible for monitoring those downstream resources and giving recommendations for adaptive management. The Colorado River through Grand Canyon contains a suite of valued natural, cultural, and recreational resources that are extensively monitored and researched by participating agencies. Arizona Game and Fish works in cooperation with Grand Canyon Monitoring and Research Center, U.S. Fish and Wildlife Service, and others to conduct long-term fish monitoring in the Little Colorado River, a tributary to the Colorado River in Grand Canyon, to fulfill Program needs.

The AGFD began monitoring fish in the Little Colorado River in 1987 to assess population trends and status of endangered humpback chub (*Gila cypha*; Robinson and Clarkson 1992). The

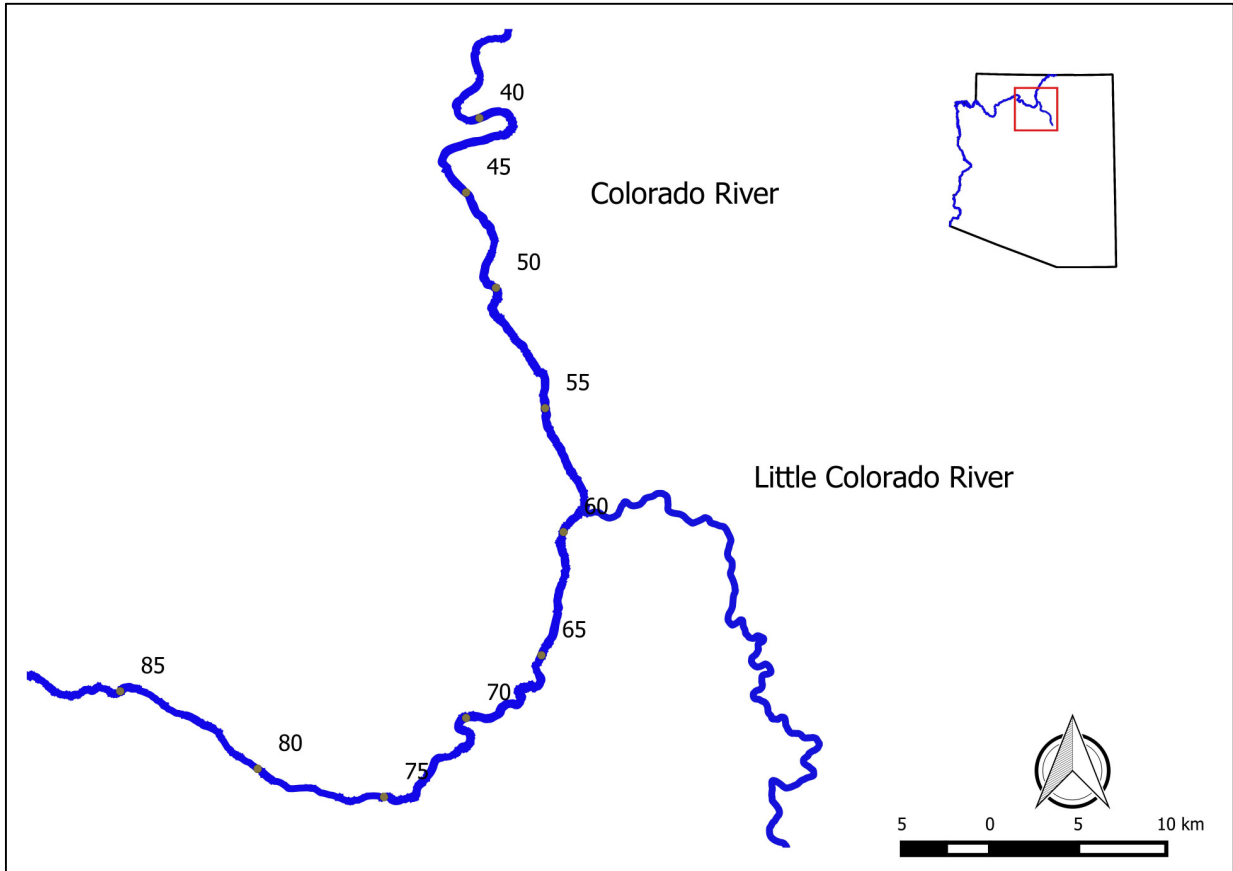
program was discontinued in 2000 but reinstated by 2002 at the advice of the Grand Canyon Monitoring and Research Center Protocol Evaluation Panel (Anders et al. 2001). With the exception of 2000 – 2001, the lower 1,200 meter sampling represents one of the most consistent, long-term sampling programs for Grand Canyon fishes (Ward and Persons 2006). Long-term monitoring establishes context through which response of biota to changing management policies or experiments can be interpreted and evaluated (Walters and Holling 1990; Thomas 1996; Walters 1997). The spring sampling effort aims to capture individuals during peak humpback chub movement to spawning grounds. Information on species composition, length-frequency distributions, and catch per unit effort estimates of humpback chub and other native species highlight trends in populations and contribute towards the adaptive management of this unique, undammed tributary. Additionally, catch per unit effort indices derived from this monitoring program are useful as independent validation for population models of humpback chub (Yackulic et al. 2014).

The humpback chub is a cyprinid fish endemic to the Colorado River basin and a federally listed endangered species since 1967 (USOFR 1967). As major dams have been built within the basin, temperature and flow regimes have been drastically altered from turbid waters with seasonal flooding to a regulated clear, cold water system with a suite of cold water predators. Currently, only six populations of humpback chub are known; five populations exist in the upper basin (i.e., above Glen Canyon Dam) and one in the lower basin (Valdez and Ryel 1995). Within Marble and Grand canyons, nine aggregations (small, isolated groups) are known to persist. However, because of both abiotic and biotic changes to the mainstem Colorado River with completion of Glen Canyon Dam, humpback chub rely on the Little Colorado River as their primary spawning and rearing habitat (Gorman and Stone 1999; Coggins et al. 2006). Not only is the LCR the primary spawning site for the humpback chub in Grand Canyon, but is the only known aggregation in the Colorado River ecosystem from which juveniles recruit into the adult population (Valdez and Ryel 1995; Coggins et al. 2006; Yackulic et al. 2014). Other native fishes that spawn in the LCR are bluehead sucker (*Catostomus discobolus*), flannelmouth sucker (*C. latipinnis*), and speckled dace (*Rhinichthys osculus*; Robinson et al. 1996). Nonnative fish present include rainbow trout (*Oncorhynchus mykiss*), common carp (*Cyprinus carpio*), fathead minnow (*Pimephales promelas*), red shiner (*Cyprinella lutrensis*), black bullhead (*Ameiurus melas*), and channel catfish (*Ictalurus punctatus*). With a paucity of food in the river, these fishes mostly consume zooplankton (Cladophora), aquatic and terrestrial invertebrates, and other fish (Marsh and Douglas 1997).

## Study Area

Standardized locations for AGFD hoop net sampling occur from the confluence of the Little Colorado River and the mainstem Colorado River, designated as river kilometer (rkm) 0, up to rkm 1.2 of the LCR (Figure 1-2). The LCR is a warm, saline, unregulated tributary to the Colorado River located within a 69,870 km<sup>2</sup> basin (Johnson 1976). The LCR headwaters originate in the White Mountains in Eastern Arizona and flow northwest through Navajo Nation tribal lands before reaching the Colorado River in Grand Canyon, some 315 miles later. The lower 21 km of the LCR maintains a perennial flow primarily from Blue Spring (rkm 21). Combined with other springs, discharge in this section of the LCR averages 223 cubic feet/second (cfs) under baseflow conditions (Cooley 1976). Water turbidities and flow in the LCR are strongly influenced by spring run-off and monsoonal rains; turbidity often ranges from below 30 nephelometric units (NTU) to the tens of thousands during flood events (Stone 2010). Water from Blue Springs is 20°C, charged with CO<sub>2</sub> and supersaturated with calcium carbonate (Cole 1975; Robinson et al. 1996; Stone 2010). Additionally, calcite precipitation increases turbidity,

imparting a cloudy blue color to the water, and covers the stream bottom with a layer of limestone (Robinson et al. 1996). Mean water depth is typically less than 1m deep with dissolved oxygen less than 10 mg/L (Kaeding and Zimmerman 1983). The deeply entrenched channel of the LCR contains runs, riffles, deep pools, and small rapids. Substrates are primarily silt and sand with scattered large boulders and travertine dams (Ward and Persons 2006). A large series of dams (Atomizer Falls Complex) at 14.2 km may be a physical barrier to upstream movement of fish (Robinson et al. 1996).



**Figure 1.** Lower 1,200 m sampling reach on the Little Colorado River before the confluence with the Colorado River at river mile 61.5. River miles on the Colorado River are approximate.



**Figure 2.** Little Colorado River lower 1,200 m sampling reach with net locations 1–13. (Map obtained from Google earth: <http://www.google.com/earth/>).

## Methods

### Gear and Effort

Between 18 April 2014 and 12 May 2014, sampling was performed to monitor status and trends of the Little Colorado River fish community. Thirteen unbaited hoop nets (0.9 m diameter, 2.6 m length, 6.3 mm mesh, with two 0.12 m throats and seven galvanized steel hoops) were set at standardized locations used in previous sampling efforts (Brouder and Hoffnagle 1998). AGFD utilized GPS, map, and picture documentation to set nets as close as possible to those locations used previously. Nets were likely originally set at these locations to maximize humpback chub catch, within constraints of river hydrology and depth. Each net set consisted of one net being deployed into the river for one ~24 hour period, after which it was checked for fish. Nets were set beginning at 1322 hours on April 18, 2014 and checked daily through May 12, 2014. Net 1 was pulled between 0800 and 1000 hours, with nets 2–13 following thereafter. Net 9 was set approximately 4 m upstream of the standardized set location, however, this was the same location set in 2012 and 2013. Net 13 was approximately 1.2 m longer (with cod end extended) than the standardized length of the other nets set during 2014. Net ends were secured

to rocks or tamarisk branches and ropes were placed flush to the ground as much as possible to prevent tripping hazards to pedestrian visitors.

**Table 1.** Net locations and habitat description for Little Colorado River lower 1,200 m monitoring.

Net number	River kilometer	Habitat description	Substrate
1	0.100	Rock ledge	Sand
2	0.119	Rock ledge	Sand
3	0.137	Rock ledge	Sand
4	0.165	Boulder complex	Sand/boulder
5	0.420	Rock ledge	Sand
6	0.480	Rock ledge	Sand
7	0.500	Rock ledge	Sand
8	0.577	Vegetative cover	Sand
9	0.675*	Travertine dam/boulder complex	Sand/boulder
10	1.045	Boulder complex	Sand
11	1.110	Travertine dam	Sand
12	1.160	Cut-bank with phragmites	Sand/boulder
13	1.195	Cut-bank with phragmites	Sand/boulder

\*Net 9 was set approximately 4 m upstream of the standardized set location

### Fish Handling

All fish captured were handled following the Standard Methods for Grand Canyon Fisheries Research 2012 (Persons et al. 2013). Fish were first identified to species and measured for total length (TL, nearest mm). Native humpback chub, flannelmouth sucker, and bluehead sucker were also measured for fork length (FL, mm). Sex was recorded for all fish, determined by manual expression of gametes (e.g., male, female, undetermined). Sexual condition (e.g., not ripe, ripe) as well as secondary sex characteristics such as color and/or tuberculate were also noted. Number and type of external parasites were recorded if observed.

Humpback chub  $\geq 100$  mm, bluehead sucker and flannelmouth sucker  $\geq 150$  mm TL were scanned for the presence of a passive integrated transponder (PIT; Biomark Inc., Boise, Idaho) tag with a 134.2 kHz Biomark® FS2001 tag reader (also known as scanner) and if none was detected, a new PIT tag was inserted into the abdominal cavity. If any captured fish possessed only an older 400 kHz PIT tag they were given a new 134.2 kHz PIT tag. Tag presence/absence and uniquely identifying PIT tag number (400 kHz and 134.2 kHz) were recorded on data sheets and saved in scanners. All fish were checked for fin clips as well as visual implanted elastomer (VIE) marks. Files were downloaded and archived to confirm the accuracy of data sheets and databases. Data was entered into a Microsoft Access® database where quality assurance and quality control using standard software routines were employed. A copy of the database was submitted to GCMRC to be incorporated into the main fish database.

## Water Quality

Turbidity (nephelometric turbidity units; NTU) and temperature (°C) data were collected each morning as a single point reading at Boulders camp (rkm 1.9) prior to daily hoop net checks (0700-0800 hours) using a Hach 2100P Turbidimeter (Loveland, CO) and a Cooper Model DPP400W thermometer. Flow data (mean daily discharges in cubic feet per second) were downloaded for USGS gage station *09402300 LITTLE COLORADO RIVER ABV MOUTH NR DESERT VIEW, AZ* ([http://waterdata.usgs.gov/az/nwis/uv?site\\_no=09402300](http://waterdata.usgs.gov/az/nwis/uv?site_no=09402300)) which is located 1.2 km upstream of the mouth of the Little Colorado River.

## Analyses

Summary statistics were calculated for Little Colorado River physical parameters, sampling effort, and fishes captured. Length frequency histograms for each native fish species were constructed to examine for differences in size distributions over the time period of this monitoring. Length-frequency histograms were based on the percent of total catch of a given total length, with size bins defined in 10 mm increments, presented for the last 10 years.

Catch per unit effort (CPUE) was used to monitor relative population trends in native and nonnative species present in the Little Colorado River. CPUE was calculated by using total soak hours per net each day and presented as mean CPUE (fish/24 hrs). Humpback chub CPUE is based on 4 size classes: < 150 mm TL (juvenile), ≥ 150 mm TL, 151 – 199 mm TL (subadult), and ≥ 200 mm TL (adult). For all other fish, CPUE is presented only for adults (≥ 150 mm TL). Incidentally, 26 samples were not included in CPUE calculations or analyses due to net collapse, rolling out of the water, set with the cod end downstream, or due to large holes ripped in the mesh. Confidence levels for CPUE were calculated at the 95% level. Regression analyses were performed using Poptools, an excel Add-in program (Hood 2010). All statistical tests analyzed in this report were considered significant at  $P < 0.05$ .

## Database

While reviewing historical reports and original datasheets, it was determined there were a number of data entry errors within the Access® database managed by GCMRC. Previous work reported a species composition table (Table 3), but it was undetermined whether those numbers included supplemental nets or not. Either way, we could not recreate the numbers within this species composition table based on the main database file.

Consequently we recalculated CPUE values for each year of sampling. We extracted data from the GCMRC main Access® database by year of sampling and by trip idea. We applied a filter to only include samples where “Start rkm” < 1.3, and including only hoop nets (based on gear code but also going through each individual sample note for early years). We used the database table for “samples” to add each net-set that had caught no fish, and the match function in Excel® to ensure we were not double counting a sample (based on sample ID), as nets that did not catch fish should be included in catch per unit effort calculations. Starting in 2014, nets that had collapsed or did not fish were coded as supplemental data (sample code 95) and not used in CPUE calculations, therefore we went back to previous years and recorded nets as supplemental if they: collapsed, rolled out of water, were lost, or had holes. Nets were recorded as supplemental if they were “partially collapsed” and did not catch fish. Nets were NOT supplemental if they were partially collapsed but did catch fish, as we assume the collapse was not significant. Historical records of fish that were found dead outside of nets, caught by hand, or dip-netted, were also considered supplemental data and not used for CPUE calculations. We added entries into the database for field notes that said “x number of speckled dace were not measured”

which were never included previously in CPUE calculations. In the species field, “blank” species from 1999 – current were corrected (or removed in the case of a lizard) as these are the years we have original field data sheets to reference. All trammel nets and fyke nets that were coded as hoop nets but noted as other gear in the Access® database were corrected and removed from our analyses. Finally, for some years no effort was recorded (time nets fished), so we calculated effort based on start and end times. No end times were recorded in 1989 so we have removed those presented catch rates from the report; the assumption of 24 hour effort per net was likely inaccurate.

Within the main Access® database there are two ways the data is organized for the Little Colorado River. One method organizes the data based on samples, with an entry for each net-set, and the other method is by individual fish. Of note, in 2013-2014 “NFC” (no fish caught) was used in the species field to indicate no fish caught (so the net-set (sample) will still show up in the database); otherwise, when attempting to calculate CPUE via the database queries, nets (samples) that caught no fish would not be included. This is counted in the database as “1” in the “total catch” field, even though no fish were caught. There were a few years prior where “blank” species were used to indicate no fish were caught, but in most cases nets that did not catch fish were not included in the fish database. We took care to ensure all CPUE calculations for all years included all nets (not including supplemental data).

## Results

In total, 1,653 fish representing eight species were captured from 13 nets over a 24 day period (312 net-set samples) during Little Colorado River lower 1,200 m monitoring in 2014 (Table 2). Native species dominated total catch, comprising 97% of all fish caught. Humpback chub were caught most frequently, followed by speckled dace, flannemouth sucker, and bluehead sucker. There were few occurrences of nonnative fish (rainbow trout, fathead minnow, black bullhead, and red shiner). Twenty four fish caught could not be readily identified to species due to their small size.

**Table 2.** Species composition in the lower 1,200 m of the Little Colorado River from 18 April 2014 – 12 May 2014.

Species	Count	Percent of Total	CPUE (fish/24 hrs)
<b>Native</b>			
Bluehead Sucker	357	21.6	1.26
Flannemouth Sucker	389	23.5	1.39
Humpback Chub	429	26.0	1.49
Speckled Dace	415	25.1	1.45
*Unidentified Sucker	17	1.0	0.05
<b>Total</b>	<b>1607</b>	<b>97.2</b>	
<b>Nonnative</b>			
Black Bullhead	5	0.3	0.02
Fathead Minnow	14	0.8	0.05
Rainbow Trout	18	1.1	0.06
Red Shiner	2	0.1	0.00

	<b>Total</b>	<b>39</b>	<b>2.4</b>	
*Unidentified Fish		7	0.4	0.00
	<b>Grand Total</b>	<b>1653</b>	<b>100.0</b>	

\*These fish were too small to identify to species.

**Table 3.** Sampling information and species composition data collected during Little Colorado River lower 1,200 m monitoring, 1987–2014. Years 2000 and 2001 were not sampled by AGFD.

Start date	End date	Trip ID	Days sampled	Total hours	Average net set time (hours)	Net sets	Black bullhead	Bluehead sucker	Channel catfish	Common carp	Fathead minnow	Flannemouth sucker	Golden shiner	Humpback chub	Plains killifish	Rainbow trout	Red shiner	Speckled dace	Unidentified fish	Unidentified sucker	Yellow bullhead
*5/9/1987	5/30/1987	LC19870509	21	1,428	11.5	124	0	48	9	2	1	83	1	483	0	0	0	141	0	0	0
*5/3/1988	5/29/1988	LC19880503	27	3,984	11.0	362	0	73	8	1	12	127	0	744	0	0	0	215	0	0	0
5/3/1989	5/28/1989	LC19890503	26	--	--	261	0	85	48	0	17	48	0	789	0	1	2	237	0	0	0
4/17/1990	5/14/1990	LC19900417	27	5,550	23.0	241	0	37	10	0	10	47	0	612	0	0	0	126	0	3	0
5/3/1991	6/30/1991	LC19910503	58	18,913	17.4	1089	0	148	8	0	8	168	0	730	0	4	0	1,647	0	0	1
5/5/1992	5/28/1992	LC19920505	24	5,987	18.9	317	0	19	8	0	1	25	0	197	0	0	0	110	0	0	0
4/30/1993	5/31/1993	LC19930430	32	9,049	12.2	739	0	44	0	0	1	50	0	428	0	2	0	455	13	1	0
4/19/1994	5/21/1994	LC19940419	33	9,964	12.3	812	0	64	5	0	265	88	0	657	0	0	0	1,022	1	0	0
4/20/1995	5/20/1995	LC19950420	31	9,440	12.0	786	0	32	1	1	19	65	0	243	0	1	0	489	0	0	1
4/18/1996	5/18/1996	LC19960418	30	9,174	12.3	749	0	413	1	8	232	241	0	360	0	8	14	741	0	2	0
4/13/1997	5/14/1997	LC19970413	32	9,063	12.1	752	0	45	12	60	726	97	0	123	97	1	74	417	0	0	1
4/5/1998	4/26/1998	LC19980405	22	7,060	16.4	431	1	27	5	0	52	6	0	132	1	4	8	106	0	0	0
4/7/1999	5/1/1999	LC19990406	24	9,373	18.9	497	0	61	10	5	14	21	0	156	0	6	70	187	0	0	0
4/20/2002	5/19/2002	LC20020419	29	8,917	24.0	372	3	299	9	2	92	540	0	430	4	5	14	763	0	0	2
4/12/2003	5/5/2003	LC20030411	24	7,152	24.3	294	5	400	4	19	79	590	0	321	2	2	56	520	0	0	0
4/10/2004	5/3/2004	LC20040409	24	7,136	24.0	297	5	154	7	7	92	354	0	746	52	5	65	1,914	0	0	0
4/9/2005	5/2/2005	LC20050408	24	6,142	23.9	257	4	347	3	1	0	190	0	344	0	1	0	444	0	0	0
4/7/2006	5/1/2006	LC20060407	24	7,417	23.8	312	12	395	13	19	1,286	483	0	586	9	1	44	3,173	0	0	0
4/15/2007	5/7/2007	LC20070414	21	6,840	25.6	267	9	304	3	13	17	644	0	266	12	0	8	1,635	0	0	0
4/11/2008	5/5/2008	LC20080411	23	6,825	25.3	270	19	565	3	1	62	596	0	504	0	0	0	1,335	0	0	0
4/17/2009	5/11/2009	LC20090417	24	7,407	24.3	305	7	330	45	1	93	1,103	0	540	1	1	2	1,003	0	0	0

Start date	End date	Trip ID	Days sampled	Total hours	Average net set time (hours)	Net sets	Black bullhead	Bluehead sucker	Channel catfish	Common carp	Fathead minnow	Flannemouth sucker	Golden shiner	Humpback chub	Plains killifish	Rainbow trout	Red shiner	Speckled dace	Unidentified fish	Unidentified sucker	Yellow bullhead
5/13/2010	6/9/2010	LC20100513	19	5,823	23.7	246	0	83	12	1	13	671	0	315	5	1	0	997	0	0	0
5/4/2011	5/29/2011	LC20110504	25	6,028	23.8	253	2	322	6	3	306	602	0	383	2	13	2	366	0	1	0
4/20/2012	5/14/2012	LC20120420	24	7,394	25.3	292	1	259	3	2	69	398	0	589	101	0	28	676	1	0	0
4/12/2013	5/5/2013	LC20130412	23	6,981	23.7	295	4	439	9	0	18	488	0	769	6	3	13	465	0	0	0
4/18/2014	5/12/2014	LC20140418	24	6,813	23.8	286	5	357	0	0	14	389	0	429	0	18	2	415	7	17	0
<b>Total (All years)</b>							77	5,350	242	146	3,499	8,114	1	11,876	292	77	402	19,599	22	24	5

\*Data represented in this table excludes supplemental coded nets (nets were collapsed, cod end came open, large holes)

\*\*Effort was not always recorded in years 1987 and 1988; therefore an average effort was used in these cases. No effort was recorded in 1989 and pull time was not recorded; therefore effort could not be extrapolated in this case. Other years that had few nets with missing effort were recoded as supplemental nets.

## Native Fish

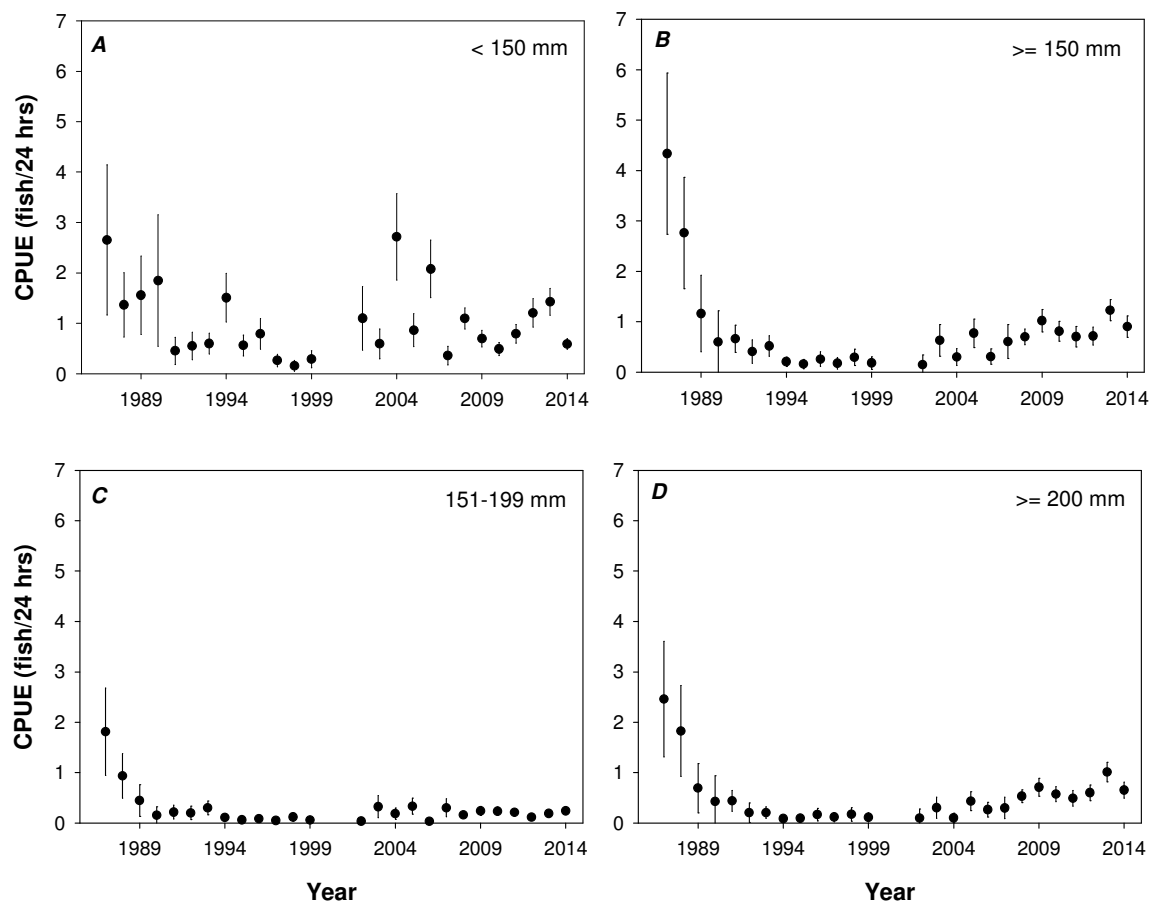
### *Humpback chub*

A total of 429 humpback chub were captured in 2014, representing the majority of total catch (26%; Table 2). Humpback chub captured in 2014 had a mean TL of 182 mm and ranged in size from 23 mm to 404 mm total length. Catch-per-unit effort was calculated as the mean of all net-sets, with 95% confidence intervals in brackets.

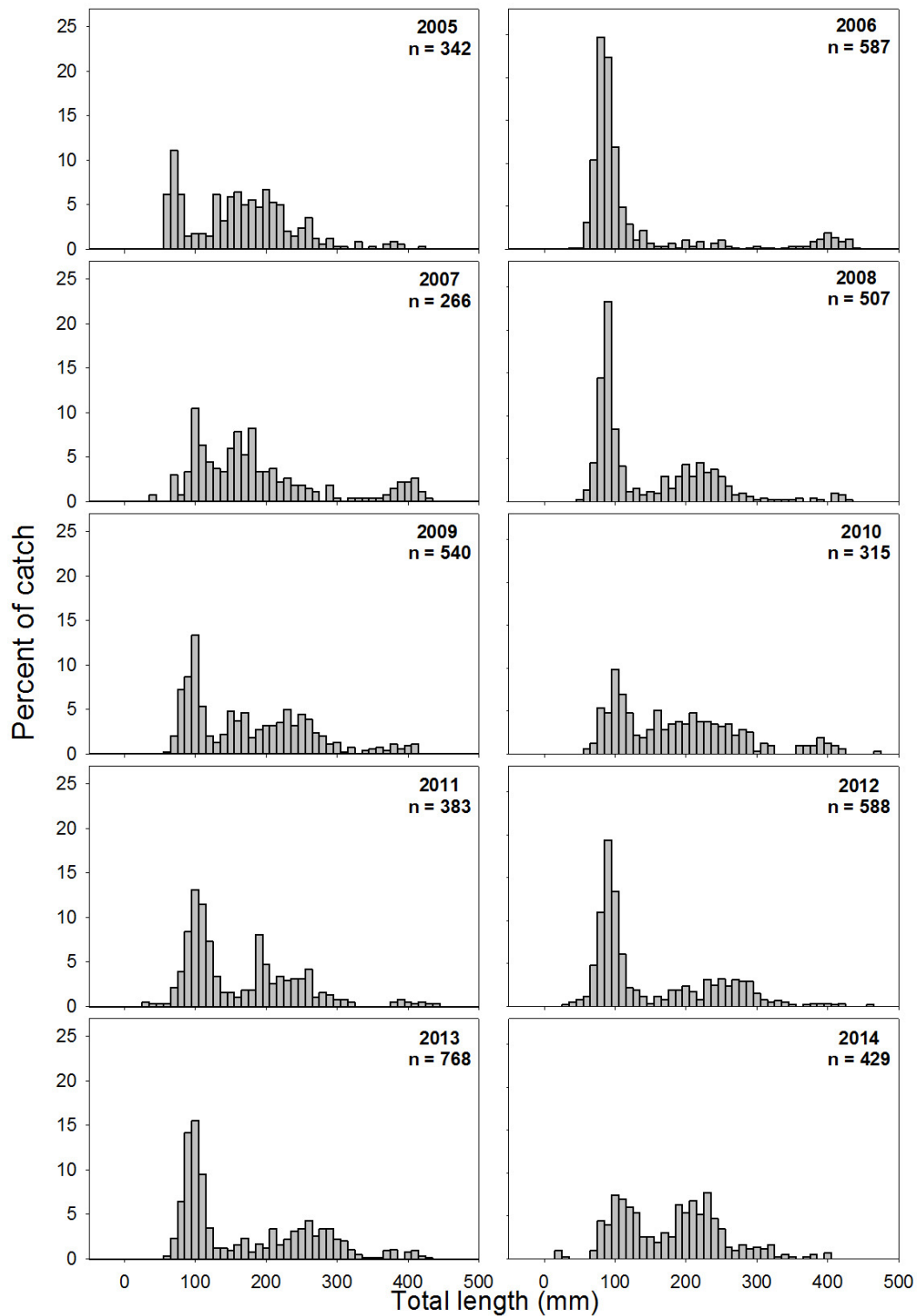
- Mean CPUE of juvenile humpback chub < 150 mm TL (0.6 fish/24 hrs [0.48, 0.70]) was considerably lower than in 2013, however, there is not a significant decrease in CPUE of juvenile humpback chub over the last five years ( $R^2 = 0.11$ ,  $F_{1,4} = 0.36$ ,  $P = 0.59$ ; Figure 3 A).
- Catch rates of subadult and adult humpback chub, those  $\geq 150$  mm TL, were higher than juveniles in spring of 2014 (0.9 fish/24 hrs [0.69, 1.11]), and have shown no significant change since 2010 ( $R^2 = 0.27$ ,  $F_{1,4} = 1.14$ ,  $P = 0.36$ ; Figure 3 B).
- CPUE of subadult fish 151–199 mm TL (0.24 fish/24 hrs [0.17, 0.32]) has been stable, with no change in trend in the past five years ( $R^2 = 0.00$ ,  $F_{1,4} = 0.01$ ,  $P = 0.92$ ) and no large changes in catch rates since 1989 (Figure 3 C).
- Mean CPUE for adult fish  $\geq 200$  mm TL (0.65 fish/24 hrs [0.49, 0.82]) was lower in 2014 than in 2013, but has not changed significantly in the past five years ( $R^2 = 0.28$ ,  $F_{1,4} = 1.19$ ,  $P = 0.36$ ) and continues to have a slight increasing trend (Figure 3 D).

There were two distinct size classes of humpback chub captured in 2014, as demonstrated by the length frequency histogram: a juvenile peak occurring around 104 mm total length, and an adult population centered around 237 mm TL (Figure 4). The bimodal distribution has been common for the past decade; however, the very strong juvenile peak (high percent of total catch) was vastly tempered in 2014.

Over half of the 384 captured humpback chub that were of tagging size were tagged by AGFD during 2014, whereby the remaining fish already contained tags. Unique humpback chub captured by AGFD that were already tagged in a prior sampling event represented 39% of total tagged humpback chub encountered in 2014 (Table 4). Additionally, 18% of the humpback chub we tagged in 2014 were recaptured again during our monitoring period. Twenty ripe male humpback chub were observed in 2014, along with 2 ripe females. No parasitic copepods (anchor worms, *Lernaea* spp.) were found on humpback chub during 2014 monitoring.



**Figure 3.** Mean CPUE (fish/24 hours) of humpback chub captured during Little Colorado River lower 1,200 m monitoring by AGFD from 1987–2014. Years 2000 and 2001 were not sampled by AGFD. Error bars represent 95% confidence intervals.



**Figure 4.** Length-frequency distributions represented by percent of total catch, of humpback chub during Little Colorado River lower 1,200 m monitoring from the past decade, 2005–2014.

**Table 4.** Passive integrated transponder (PIT) tag recapture information for humpback chub  $\geq 100$  mm TL, bluehead sucker  $\geq 150$  mm TL, and flannemouth sucker  $\geq 150$  mm TL during the 2014 Little Colorado River lower 1,200 m monitoring. Recapture data was filtered to represent one unique PIT tag number per fish (i.e., no duplicates).

Species	Number of fish captured	Number of fish tagged by AGFD in 2014*	Unique fish recaptures tagged in a prior event	Unique fish recaptures tagged by AGFD in 2014	Percent of fish captured that were tagged in a prior event
Humpback chub $\geq 100$ mm TL	384	198	126	35	38.9%
Bluehead sucker $\geq 150$ mm TL	282	268	8**	4	2.9%
Flannemouth sucker $\geq 150$ mm TL	355	292	50	10	14.6%

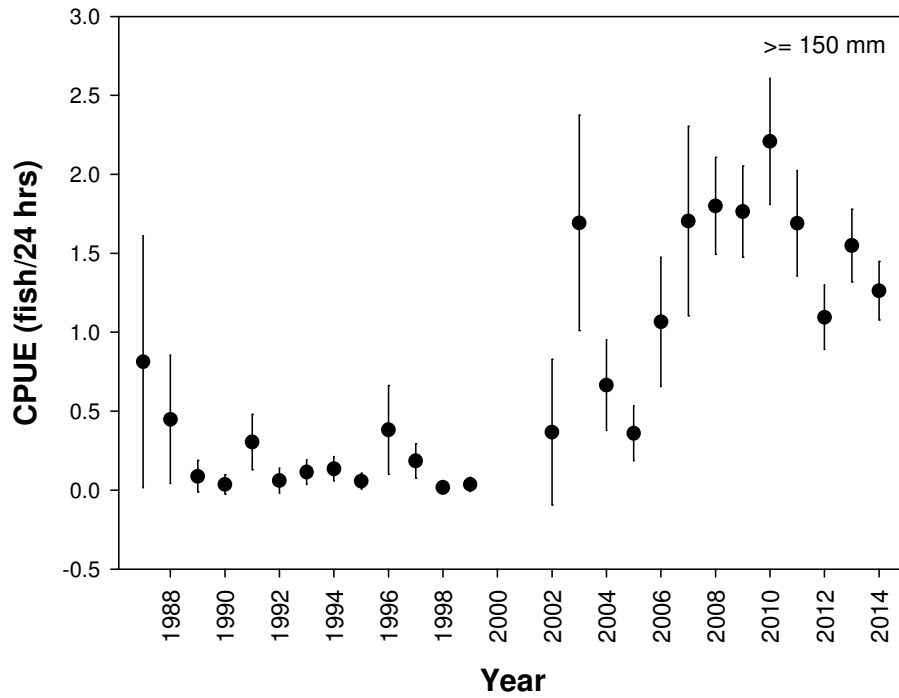
\*Some fish did not receive PIT tags due to fish escaping or incidental release before receiving a tag.

\*\*One bluehead sucker received a 134.2 kHz tag but may have already had one (antenna wasn't functioning properly); therefore this fish was counted as tagged but noted as "undetermined" for a recapture and not counted as a recapture.

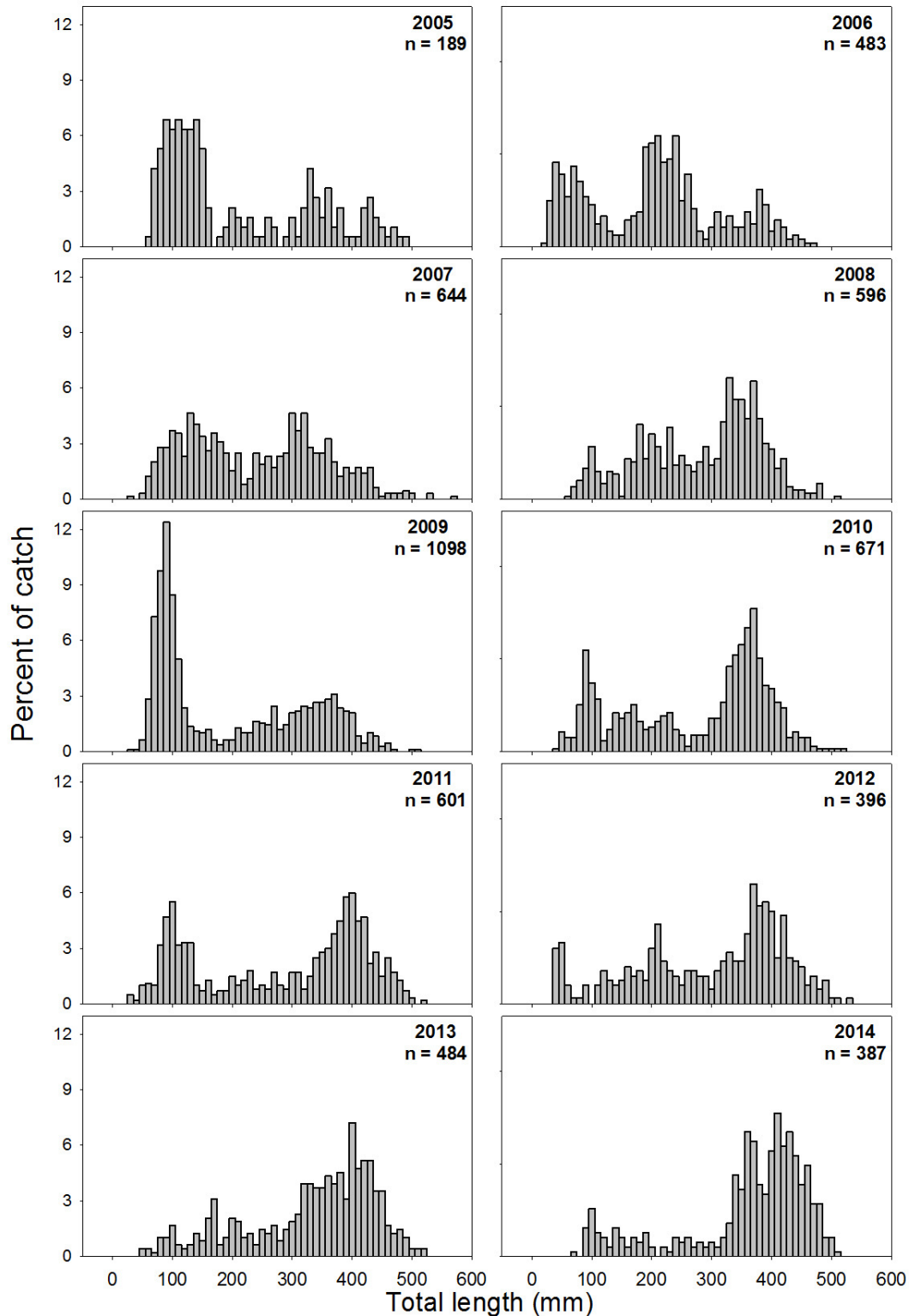
#### *Flannemouth sucker*

In 2014, flannemouth suckers accounted for 24% of total catch (Table 2). Flannemouth sucker captured in 2014 had a mean TL of 363 mm and ranged in size from 79 mm to 511 mm total length. Mean CPUE of flannemouth sucker  $\geq 150$  mm TL (1.3 fish/24 hrs [1.08, 1.45]) has declined since 2010, though not significantly ( $R^2 = 0.56$ ,  $F_{1,4} = 3.84$ ,  $P = 0.14$ ; Figure 5). Over 91% of captured flannemouth suckers were  $\geq 150$  mm TL. The size distribution of flannemouth suckers displays two distinct size classes of adults with modes centered at 420 mm TL and 360 mm TL, as well as a smaller juvenile cohort at 100 mm TL (Figure 6).

There were 355 flannemouth sucker  $\geq 150$  mm TL caught in 2014, of which 82% were tagged by AGFD during monitoring. Unique flannemouth suckers captured that were tagged in a prior event represented 15% of total tagged flannemouth suckers encountered (Table 4). Eighteen of the captured flannemouth suckers were ripe, of which 10 were male and 8 were female. No *Lernaea* spp. were found on flannemouth suckers during the 2014 monitoring period.



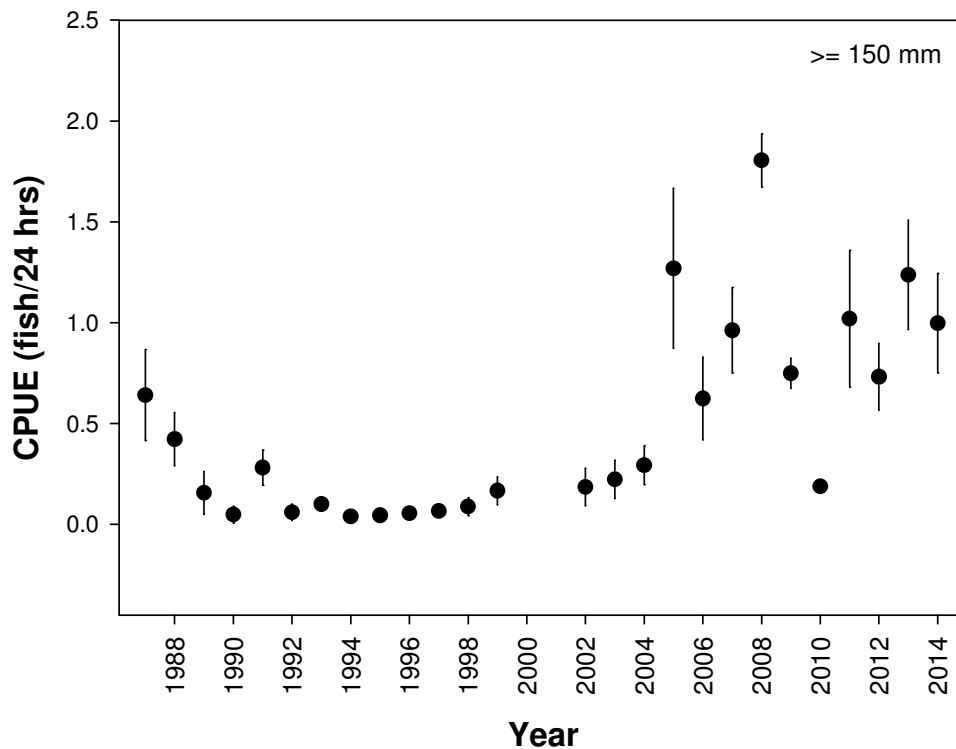
**Figure 5.** Mean CPUE (catch/24 hrs) of flannemouth sucker  $\geq 150$  mm TL captured during Little Colorado River lower 1,200 m monitoring, 1987–2014. Years 2000 and 2001 were not sampled by AGFD. Error bars represent 95% confidence intervals.



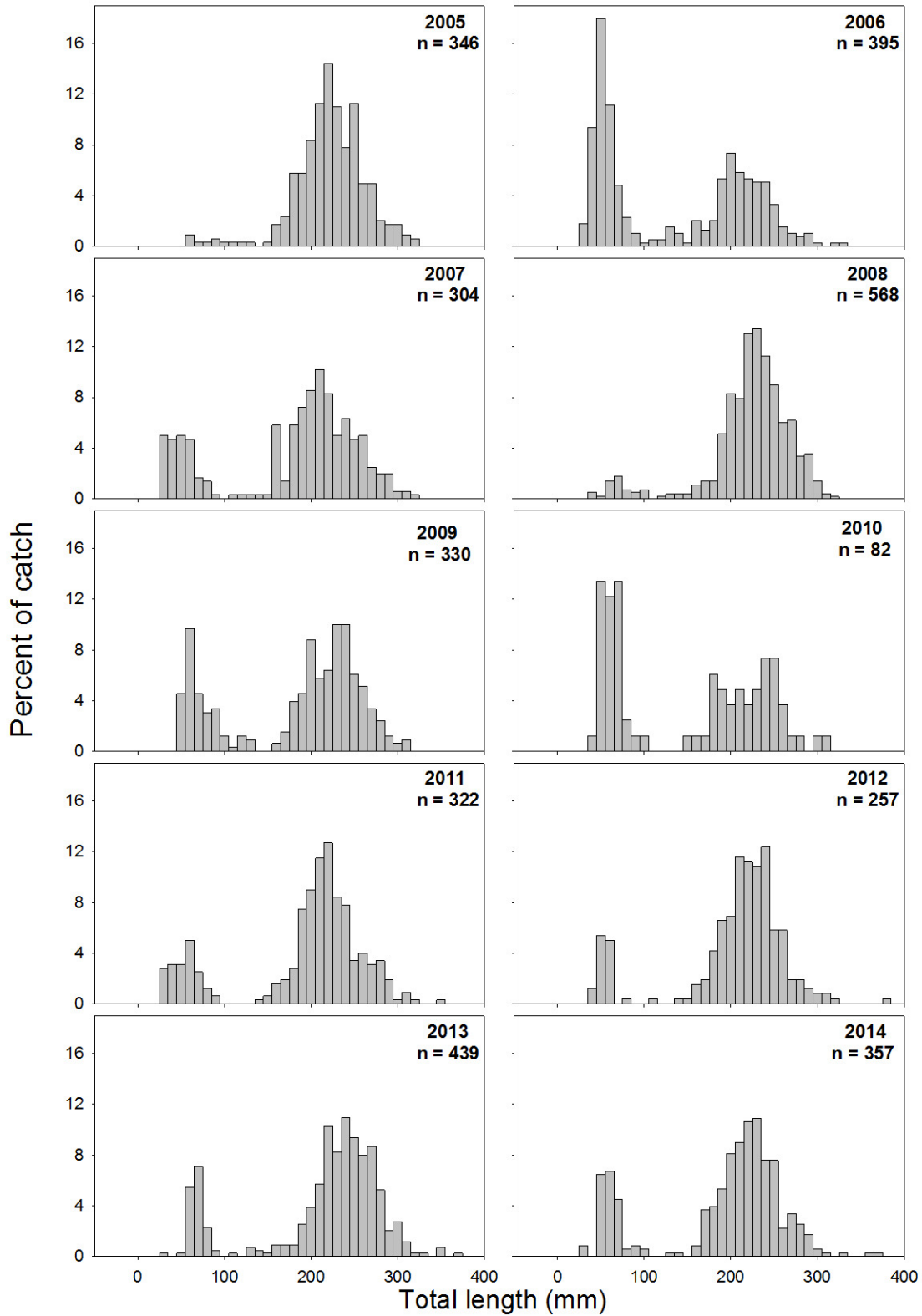
**Figure 6.** Length-frequency distributions of flannelmouth sucker captured during Little Colorado River lower 1,200 m monitoring from the past decade, 2005–2014.

*Bluehead sucker*

In 2014, bluehead suckers accounted for 22% of total catch (Table 2). Bluehead sucker captured in 2014 had a mean TL of 195 mm and ranged in size from 30 mm to 379 mm TL. Mean CPUE of bluehead sucker  $\geq 150$  mm TL (1.0 fish/24 hrs [0.75, 1.24]) has shown no significant change since 2010 ( $R^2 = 0.52$ ,  $F_{1,4} = 3.24$ ,  $P = 0.17$ ; Figure 7). There were two distinct size classes of bluehead sucker captured in 2014, similar to previous years: a distinct juvenile cohort at 65 mm TL and an adult cohort around 240 mm TL (Figure 8). The majority of captured bluehead suckers (79%) were  $\geq 150$  mm TL. Over 95% of bluehead sucker  $\geq 150$  mm TL captured were tagged by AGFD this year (2014). Very few fish were recaptures tagged from a prior event (3%; Table 4). Of the 356 bluehead suckers captured, 130 were ripe, of which 106 were male and 24 were female. No *Lernaea* spp. were found on bluehead suckers during the 2014 monitoring period.



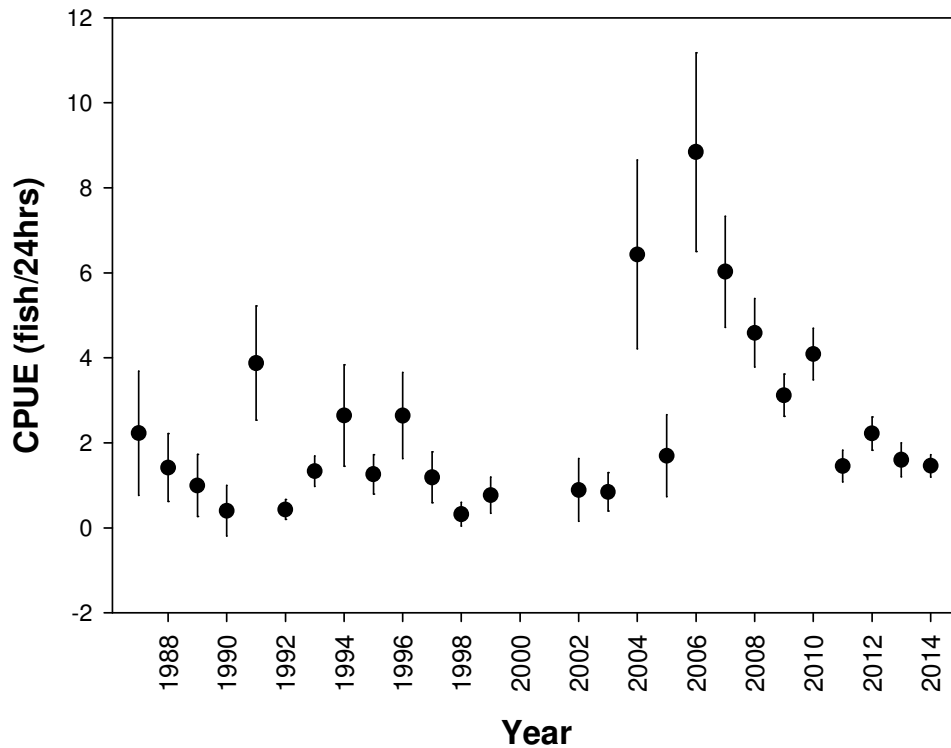
**Figure 7.** Mean CPUE (catch/24 hrs) of bluehead sucker  $\geq 150$  mm TL captured during Little Colorado River lower 1,200 m monitoring, 1987–2014. Years 2000 and 2001 were not sampled by AGFD. Error bars represent 95% confidence intervals.



**Figure 8.** Length-frequency distributions of bluehead sucker captured during Little Colorado River lower 1,200 m monitoring from the past decade, 2005–2014.

### Speckled dace

In 2014, speckled dace accounted for 25% of the total catch (Table 2). Mean CPUE of all speckled dace in 2014 (1.5 fish/24 hrs [1.20, 1.72]) was similar to levels observed since 2010 ( $R^2 = 0.52$ ,  $F_{1,4} = 3.23$ ,  $P = 0.17$ ), but has continued to experience a significant decline since a record high in 2006 ( $R^2 = 0.81$ ,  $F_{1,8} = 30.04$ ,  $P < 0.001$ ; Figure 9). AGFD captured 415 speckled dace in 2014, ranging from 24 mm TL to 122 mm TL. None of the speckled dace were observed to be infected with *Lernaea* spp.



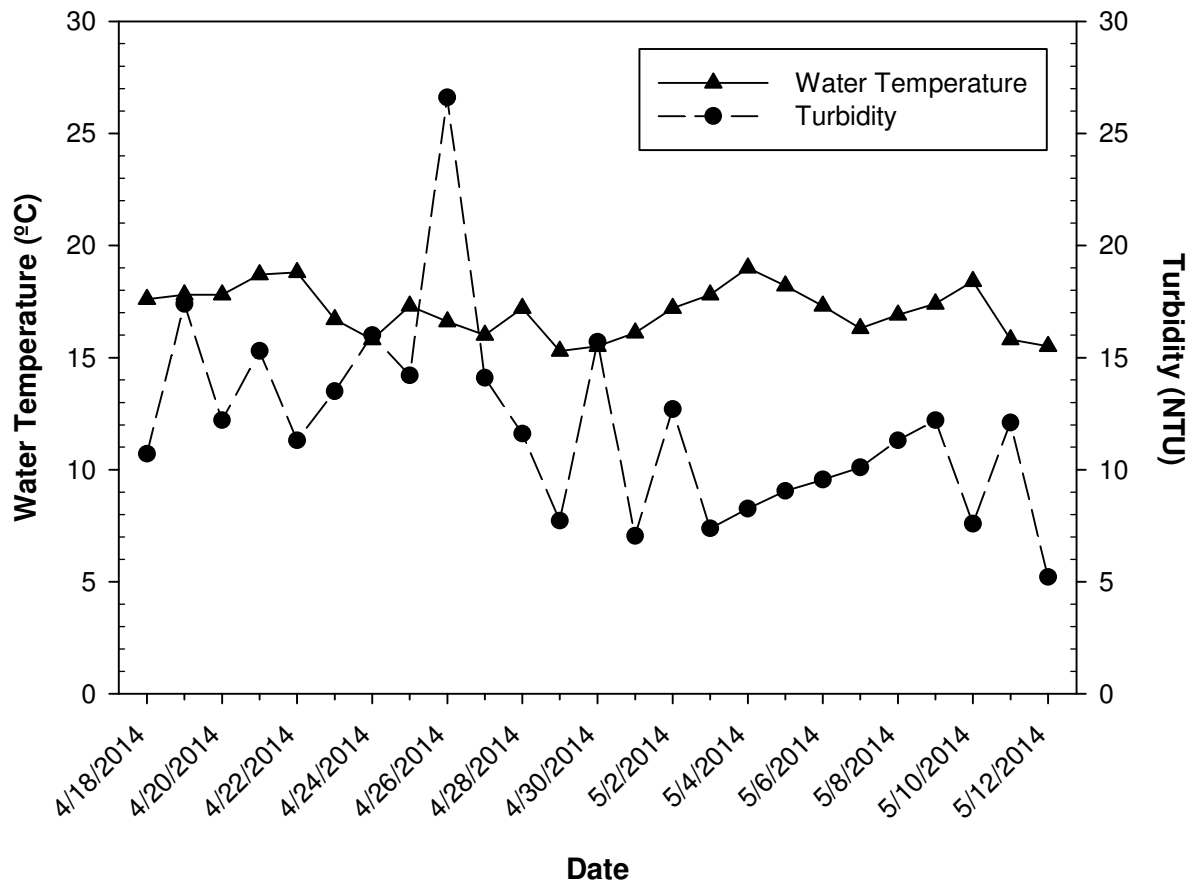
**Figure 9.** Mean CPUE (catch/24 hrs) of all speckled dace captured during Little Colorado River lower 1,200 m monitoring, 1987–2014. Years 2000 and 2001 were not sampled by AGFD. Error bars represent 95% confidence intervals.

### Nonnative Fish

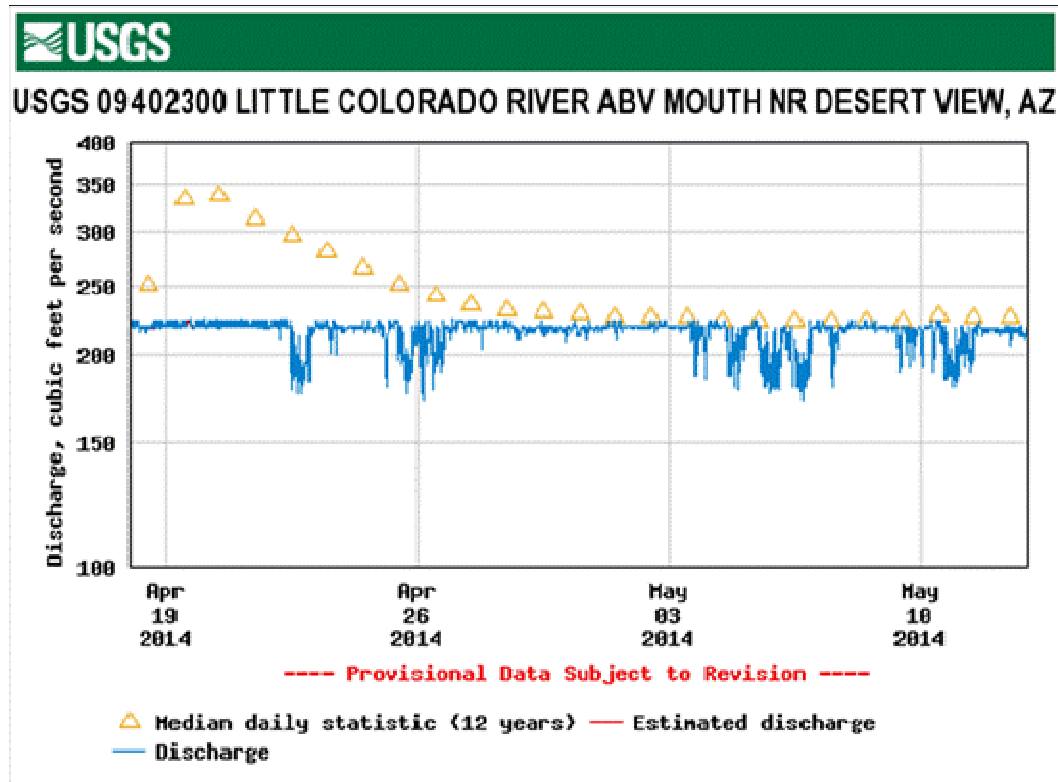
Nonnative species represented 2.4% of total catch in 2014 (Table 2). Rainbow trout and fathead minnow were the most abundant nonnative species caught. Rainbow trout were an average of 310 mm TL and fathead minnow were an average of 66 mm TL. However, with only 18 and 14 individuals captured respectively, no additional data summaries or statistical analyses were conducted for these species. The 18 rainbow trout captured was the most since AGFD began sampling in 1987. In contrast, the catch of fathead minnows was one of the lowest in the past decade. Additionally, five black bullhead and two red shiners were caught.

### Abiotic Conditions

During the 2014 monitoring period, water temperature was on average 17.1 °C (range of 15.3–19.0 °C; Figure 10). Mean turbidity was 12 NTU and ranged from 5.2–26.6 NTU throughout the monitoring period. When hoop nets were set on April 18, 2014, discharge of the LCR measured 220 cfs and ranged from 172–225 cfs throughout the monitoring period (Figure 11).



**Figure 10.** Daily water temperature (degrees Celsius) and turbidity (NTU; nephelometric turbidity units) measured at Boulders camp (river kilometer 1.9), Little Colorado River, April 18–May 12, 2014.



**Figure 11.** Daily discharge (cubic feet/second) from the Little Colorado River, AZ during the 2014 monitoring period. (Graph obtained from USGS: <http://waterdata.usgs.gov/az/nwis/rt>).

## Discussion

### Native fish

Catch rates of native fishes in 2014 were generally lower than in 2013, with the exception of subadult humpback chub, but not statistically significant. Overall, catch rates of native fishes have been relatively stable for the past decade.

Mean catch rates for humpback chub  $\geq 150$  mm TL have not changed significantly over the past 5 years. Mean CPUE of small humpback chub ( $< 150$  mm TL), though a substantial decline from 2013, has not decreased significantly since 2010. One potential explanation for varying catch rates could be due to the magnitude and timing of seasonal floods. High spring flood events in the Little Colorado River may cleanse gravel substrate, providing favorable spawning conditions, and thus increasing production of humpback chub (Gorman and Stone 1999; Van Haverbeke et al. 2013). However, catch rates of small humpback chub may decrease immediately during flood events as fish are forced to disperse into the mainstem Colorado River (Valdez and Ryel 1995). We also hypothesize that as the areal extent of the Little Colorado River increases due to high water levels in the Colorado River, the likelihood of capturing fish declines as hoop nets are sampling a smaller percentage of the available habitat. Regardless, the humpback chub population below Glen Canyon Dam is likely dependent on the Little Colorado River for reproduction and juvenile survival (Gorman and Stone 1999; Coggins and Walters 2009). Humpback chub maturity and growth rate are highly dependent on water temperature (Coggins 2007), and growth rates are higher for chub in the LCR than the mainstem (Minckley 1991; Valdez and Ryel 1995; Clarkson and Childs 2000). Humpback chub, as well as flannelmouth sucker and bluehead sucker

stage near the mouth of the LCR in March and April, and ascend into the LCR in April and May (Valdez and Ryel 1995; Gorman and Stone 1999). While this sampling protocol is designed to catch fish during their spawning migration, the possible presence of skip-spawners, as well as trap avoidance, likely means not all adult fish are caught by hoop nets.

Though both flannemouth sucker and bluehead sucker catch rates declined in 2014 from 2013, there has been no significant declining trend in the past five years. In general, mean CPUE of flannemouth sucker and bluehead sucker  $\geq 150$  mm TL in 2014 have increased to more than twice the rate of catch observed in 2002. Flannemouth sucker and bluehead sucker may both have benefited from removal of nonnative species above and below the confluence of the Little Colorado River during 2003-2006 (Coggins et al. 2011). Also of note, warmer than average mainstem water temperatures caused by drought conditions and lower water levels in Lake Powell began in 2003 (Ryan, personal communications), which may also have promoted survival and recruitment of these suckers.

Speckled dace catch has significantly declined since a record high in 2006. However, speckled dace mean CPUE has remained relatively consistent over the past 5 years, similar to speckled dace catch rates in the 1990's.

### **Nonnative fish**

Low capture rates of nonnative fish may be due to either low abundance or sampling gear selectivity. Some fish species such as adult common carp tend to avoid hoop nets but are often observed by field crews; channel catfish are commonly captured by angling. However, hoop netting does provide presence-absence data for most nonnative fishes, and the following species have been caught at some point in the Little Colorado River (lower 1,200 m): black bullhead, channel catfish, common carp, fathead minnow, golden shiner, plains killifish, rainbow trout, red shiner, and yellow bullhead. As none of these species have been caught in high numbers (besides fathead minnow), the unique desert stream conditions of the Little Colorado River likely do not facilitate survival of nonnative fishes. Previous reports suggest that years with low spring runoff correlate with higher catch rates of small-bodied nonnative fishes such as fathead minnow and red shiner, when they were less likely to have been displaced into the mainstem Colorado River. The pattern of nonnative fish capture rates in the LCR is not typical of most southwestern streams. Typically, once small-bodied introduced species appear, they gradually increase in abundance over time until they numerically dominate a fish assemblage (Marsh and Pacey 2005). The extreme flood regime, high turbidity, and high salinity of the LCR during spring and late summer may prevent these nonnative species which are adapted for more stable systems, from becoming established (Minckley and Meffe 1987; Ward et al. 2003).

Nonnative fishes threaten native fishes in the Colorado River (Valdez and Ryel 1995). As such, the Glen Canyon Dam Adaptive Management Program began a removal program for nonnative fishes and removed more than 19,000 rainbow trout between 2003 and 2006 in the mainstem Colorado River around the LCR (Coggins 2008; Coggins et al. 2011; Yard et al 2011). Besides rainbow trout, nonnative fathead minnow, common carp, and brown trout were captured and removed. The higher number of rainbow trout captured in the Little Colorado in 2014 compared to previous years may suggest a rebound or recolonization of this aggregation at the confluence of these two rivers. It is likely that the natal source of most rainbow trout in the Colorado River system is the Lees Ferry reach, some 65 miles upstream (Coggins et al. 2011). As stated previously, the abiotic conditions of the Little Colorado River are likely less conducive to cold-water nonnatives, such as rainbow trout, than the mainstem Colorado River.

## Acknowledgements

This report would not be possible without the support of the U.S.G.S. Grand Canyon Monitoring and Research Center, in particular the logistical expertise and support of Carol Fritzinger and Seth Felder. Additionally, we thank volunteers of Arizona Game and Fish for donating their time and energy to this project.

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